MASTER OF SCIENCE
IN
AERONAUTICAL ENGINEERING

AN EXPERIMENTAL INVESTIGATION OF FLAPPING WING PROPULSION FOR MICRO AIR VEHICLES

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Flapping-wing propulsion is studied experimentally through thrust measurements and flow visualization. The objective of the research is to provide further insight into the aerodynamics of flapping-wing micro air vehicles (MAVs). Experimental work is conducted in the NPS 1.5 m x 1.5 m in-depth wind tunnel. A previously constructed model is suspended by thin wires and is used to measure the thrust performance of the flapping-wing MAV. For this experiment, the model is tested in four configurations; three with varying wing mount stiffness and the fourth with an articulated pitch mechanism. Thrust is indirectly determined using a laser range-finder to measure stream-wise deplacement of the model. Three methods of flow visualization are attempted to gain further insight into the flow-field around the MAV. First tufts are placed on and around the model to identify the flow-field. Second, a smoke rake placed outside the tunnel is used to route smoke into the test section. Thirdly, a smoke wire system is used to produce smoke in the test section. Experimental results are compared with flow visualization results and previous experimental and numerical work.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Other (Micro Air Vehicles)

KEYWORDS: Flapping Wing, Micro Air Vehicle, Low Reynolds Number, Flow Visibility

EA-6B FOLLOW-ON STUDY: UAVS AND UCAVS

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The DoD's only air-based EA jamming capability is provided by 123 EA-6B Prowlers. It is projected that these 123 aircraft will no longer adequately support required Airborne Electronic Attack (AEA) missions beyond the year 2010 due to attrition and airframe life limits. In order to maintain the tactical advantage over enemy air defenses, the DoD must augment and ultimately replace its aging and diminishing fleet of EA-6B aircraft with an equal or better AEA capability. Integrated Product Teams (IPT) are conducting an Analysis of Alternatives (AOA) to define operational requirements that address the DoD's AEA needs. The principal contribution of this thesis is to identify those unmanned aerial vehicles (UAVs) and unmanned combat aerial vehicles (UCAVs) that can be utilized in the future for AEA. UAV Electronic Warfare (EW) payloads and smart weapons that could help in this area are presented as well. While much has already been written concerning UAVs, few resources exist that discuss the feasibility of UAV programs in the realm of EW. Even fewer resources discuss how these unmanned platforms must be linked in the future to conduct network-centric warfare. This thesis attempts to bridge that gap.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Electronic Warfare, Other (Airborne Electronic Attack)

KEYWORDS: Airborne Electronic Attack, EA-6B, Electronic Attack, Electronic Warfare, Jamming, Network Centric Warfare, Payloads, Precision Guided Weapons, Smart Weapons, UAV, UCAV

TRANSONIC COMPRESSOR TEST RIG REBUILD AND INITIAL RESULTS WITH THE SANGER STAGE

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The NPS Transonic Compressor Test Rig was rebuilt and initial testing was conducted on the Sanger Stage, which was designed using CFD techniques. Improvements to the existing monitoring equipment, test rig instrumentation, and data acquisition software were all made in preparation for testing. A Plexiglas casewall was chosen to accommodate pressure-sensitive paint measurements. Wall heating was used to control tip-clearance. The initial performance data, to 70% design speed, were compared with predictions using a 3-dimensional viscous code.

DoD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Compressor, Transonic, CFD, Turbomachinery, Tip Clearance

IMPLEMENTATION OF A TWO PROBE TIP-TIMING TECHNIQUE TO DETERMINE COMPRESSOR BLADE VIBRATIONS

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This study involved the implementation and validation of a blade-tip time of arrival (TOA) measurement technique, and the development of a computer program to analyze TOA data using a recently published approach. The program was used to analyze experimental compressor data taken in-house using two laser light probes, data generated computationally, and data obtained by others in a compressor test. The in-house compressor data was compared successfully to amplitudes obtained by strobed digital photography. A resonance was successfully detected in the supplied compressor data set.

DoD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Tip-timing, Non-Contact Measurement, Blade Vibration

OPTIMAL PARACHUTE GUIDANCE, NAVIGATION, AND CONTROL FOR THE AFFORDABLE GUIDED AIRDROP SYSTEM (AGAS)

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This study is a continuation of a previous work concerning the Affordable Guided Airdrop System (AGAS), a parachute system that integrates low-cost guidance and control into fielded cargo air delivery systems. This thesis sought to expand upon the previous study and provide more information and research on this innovative and critical military system. Several objectives and tasks were completed in the course of this research and development. The simulation model used in the previous work for feasibility and analysis studies was moved from a MATLAB/SIMULINK® environment to a MATRIX-X® environment in anticipation of AGAS future use on an Integrated Systems, Incorporated AC-104 real-time controller. Further simulation and study for this thesis were performed on the new system. The new model implemented characteristics of the G-12 parachute, which eventually will be used in the actual flight testing of the AGAS airdrop. The system of pneumatic muscle actuators (PMSs) built by Vertigo, Incorporated, and used on the AGAS was modeled on the computer also. The characteristics of this system and their effects on AGAS guidance and control were studied in depth. The control concept of following a predicted trajectory based on certain wind predictions and other ideas for control algorithms to minimize fuel gas usage, number of control actuations and final control error were also studied. Conclusions and recommendations for further study were drawn from this project.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Parachute Navigation Guidance and Control)

KEYWORDS: MATRIX-X® Software, Parachute, Guidance, Navigation, Control, Simulation, Wind Estimation